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Title: Physics-Based Modeling of Space Weather During Large and Extreme Geomagnetic Storms

Author(s): Morley, Steven Karl

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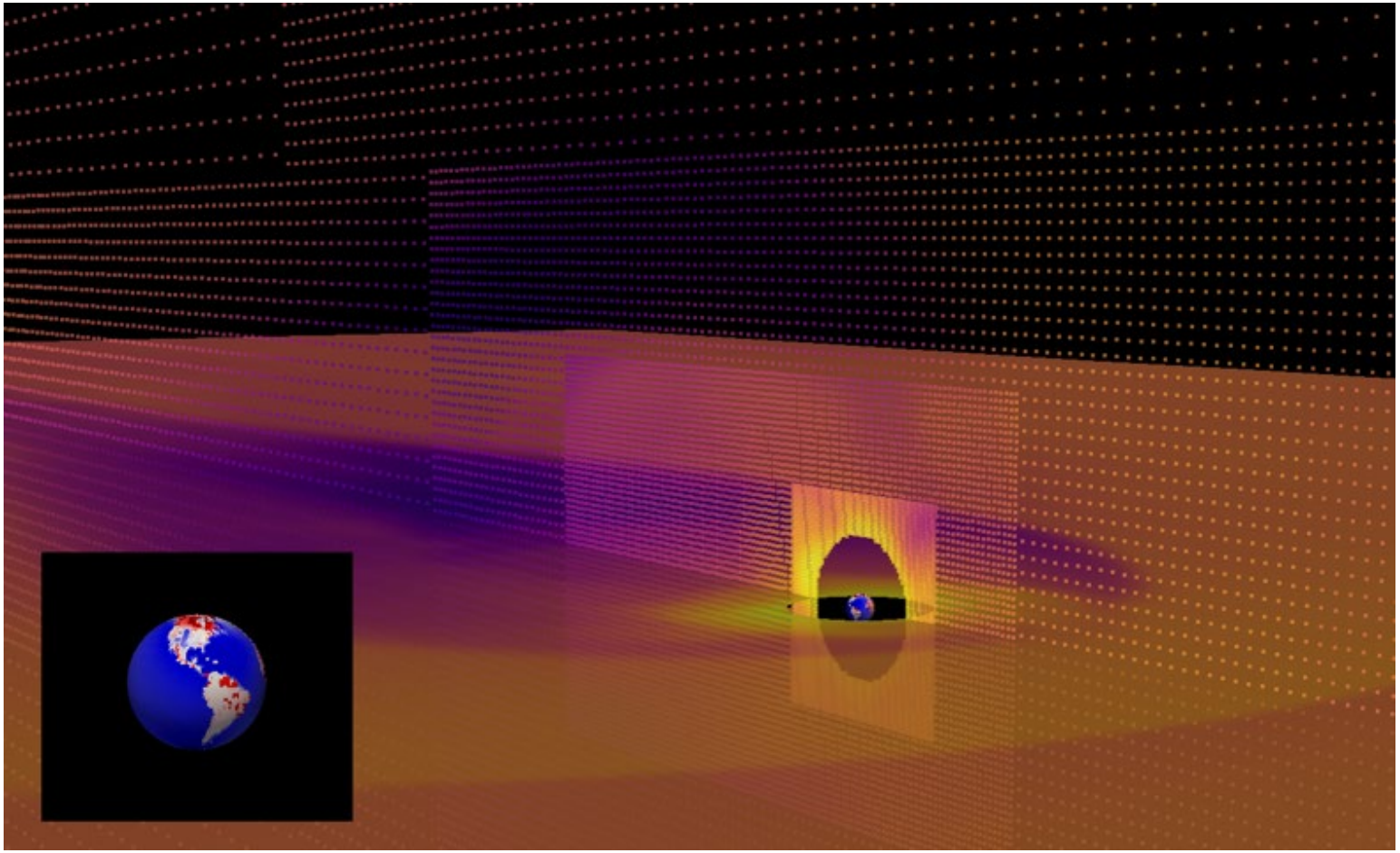
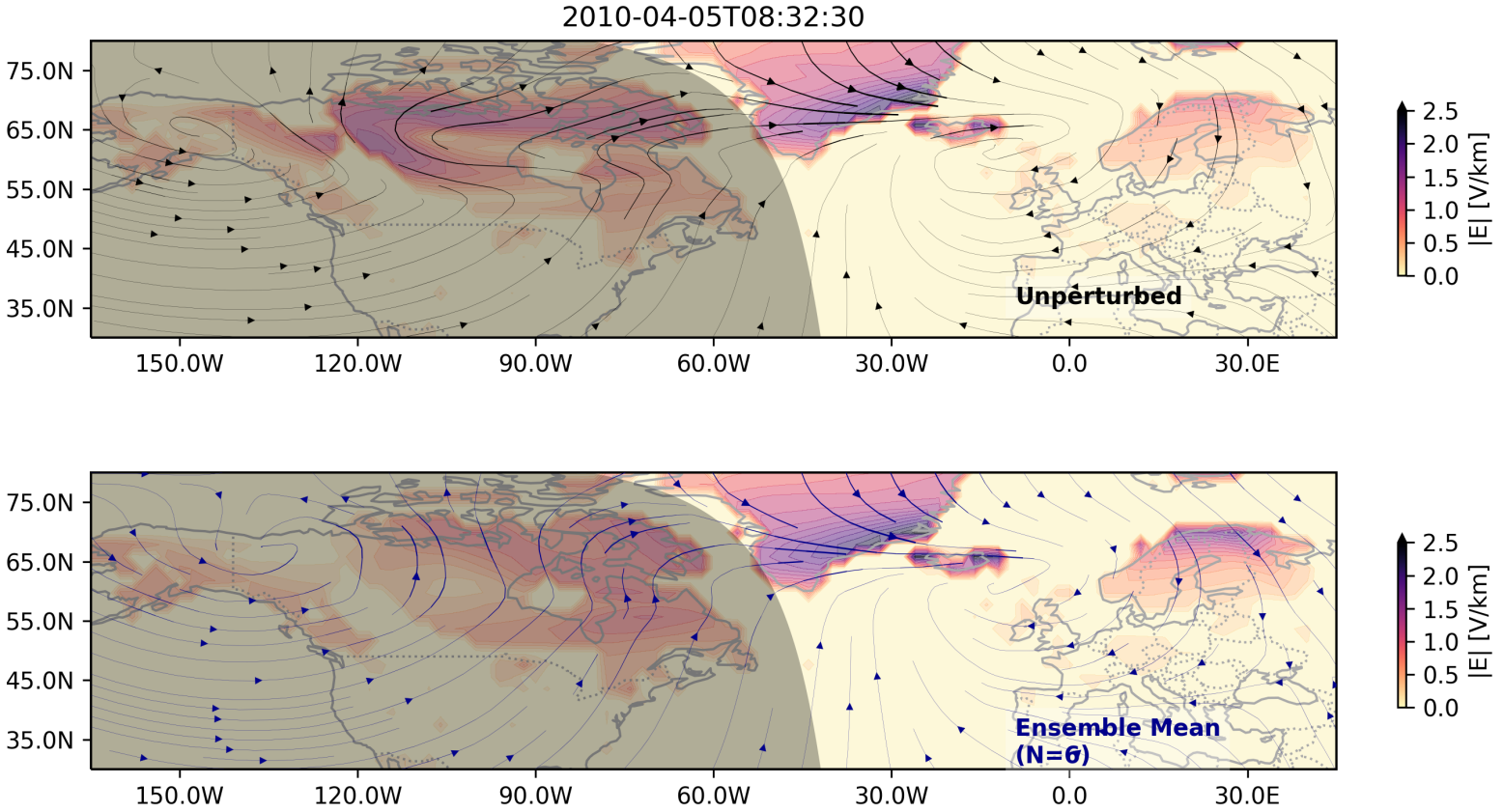
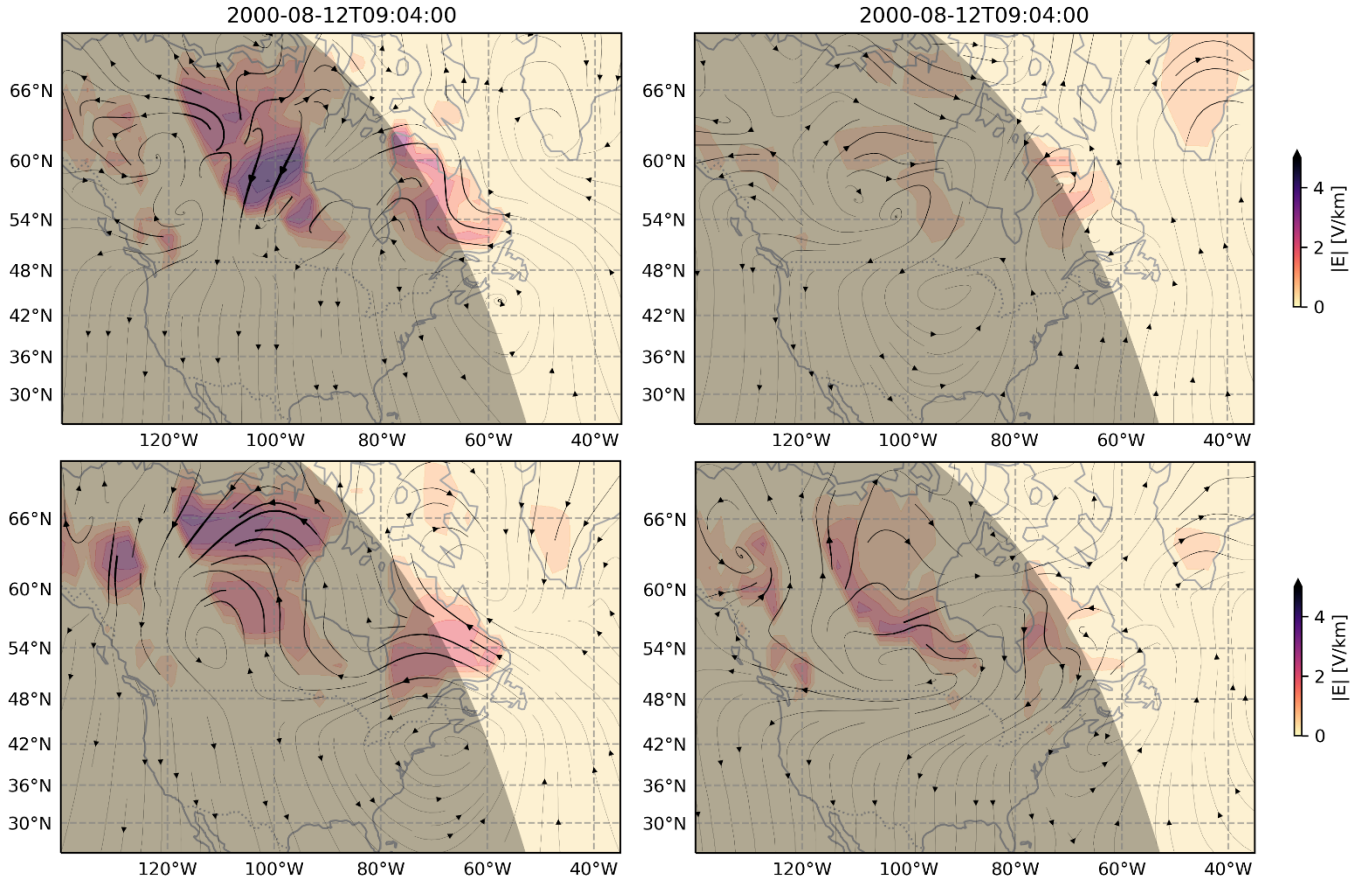
PI: Steven K. Morley



Results from the SHIELDS space weather prediction framework. The color shows the proton number density. The vertical slice shows a point at the center of each grid cell, illustrating the multi-resolution grid. The inset shows a close-up of Earth, with the predicted geoelectric field – high geoelectric field increases the technological hazard and can impact power transmission systems.



Geoelectric field predicted by the SHIELDS space weather framework. The top panel shows the results for an unperturbed simulation. The bottom panel shows the ensemble mean geoelectric field for a small perturbed input ensemble. The perturbed input ensemble captures uncertainty in the driving and uses the same configuration as NOAA's operational geospace model.



Maps of geoelectric field predicted by the SHIELDS space weather framework using a model configuration with approximately double the resolution of NOAA's operational geospace model. Each panel shows the predicted geoelectric field over North America for the same timestep in a different member of a perturbed input ensemble.